2. APPROACH

The approach for investigating program implementation scenarios included four activities. These four activities provided the transition from single-phase construction of the reference program facilities to sequential construction of facility modules before and during waste receipt and emplacement operations.

The first activity identified how CRWMS facilities could be constructed in modules. Modules were postulated for the repository waste handling building (WHB), and the repository subsurface. Portions of the repository surface facilities were treated as modules that could be deferred if temporary facilities and service contracts were used to perform their functions. The modules and their costs are described in Sections 3 and 4. Since these modules were not optimized for a particular scenario, further design activity will be required to develop the most efficient modularization for the scenario(s) of future interest.

The second activity was to formulate implementation scenarios that utilize modules as sequential building blocks. Nineteen scenarios with modularized facilities were formulated. The approach to formulating scenarios is described in Section 2.1.

The third activity was to formulate measures that describe the effectiveness of CRWMS acceptance of wastes from utilities and defense sources. The effectiveness measures are detailed in Section 2.2.

The fourth activity was to estimate the costs and benefits for the scenarios. Nine implementation scenarios, including the reference program scenario, were chosen as the focus for the most comprehensive evaluations of six potential changes to the program. These potential changes include:

- Modular construction of repository facilities
- Starting receipt in 2007 or 2008
- Alternatives to the Nevada transportation infrastructure assumed in the reference program scenario
- Deferral of facility construction or Nevada transportation upgrades past 2010 or 2020
- Augmentation of the CRWMS capability to transfer canisters to dry storage
- Magnitudes of annual receipt rates.

Eight of the nine implementation scenarios utilize modularized repository facilities. The ninth scenario is the reference program scenario. The analysis of these nine scenarios included estimation of the annual costs incurred before the start of waste emplacement.

2.1 IMPLEMENTATION SCENARIO FORMULATION

Each scenario was formulated by using one or more of the following techniques: (1) deferring construction of surface facility and subsurface facility modules, (2) deferring construction of Nevada transportation upgrades or substituting a lower cost alternative to the reference rail branch line, and (3) deferring maximum reference program scenario waste acceptance rates. The formulation of each scenario included selection of modules to be completed first, selection of schedules for deferred construction, and selection of rates of waste pickup.

Scenario schedules were formulated so that the construction of deferred modules would be completed by 2020 or shortly thereafter. This approach was chosen in order to focus on the impacts of changing from the reference program approach to a modular approach. Numerous alternative strategies are possible. One strategy is to extend the deferral of construction of the full reference system capability. One scenario was analyzed to illustrate the impacts of that strategy. Other strategies could limit the construction to a portion of that needed to support the reference system acceptance or emplacement rates. Scenarios were not formulated for those strategies.

Scenarios that included shipment of commercial SNF in large casks were formulated so that the CRWMS would eventually support waste receipt rates as large as those described in the *CRWMS Requirements Document* (DOE 1998c, page 10). Those scenarios that utilized only legal weight trucks for commercial SNF were formulated so that the CRWMS would eventually support waste receipt rates equal to the capability of the reference system to unload waste from legal weight trucks.

Emplacement operations start in 2010 for all scenarios. Emplacement rates for scenarios that utilized a modularized subsurface facility were selected to ensure that the first subsurface module would not be filled until the second subsurface module was available. Waste received in excess of emplacement rates was temporarily stored on the surface until sufficient subsurface capacity was available.

The modules and rates of waste acceptance were phased to provide an approximately constant annual cost profile, without the effects of inflation, through 2009 or through 2020 if necessary to complete construction. Figure 2-1 illustrates the target annual cost profile with the effects of inflation. The target profile is constant between 2004 (the year that follows the 5 years included in the FY1999 budget) and 2007 (the last year of the 10-year scoring period of the Balanced Budget Act). The target annual cost in each of the years following 2007 is equal to the target cost in 2007 adjusted for inflation. This approach was selected in order to foster scenario comparisons that would be useful for estimating the impacts of phased modular implementation. Other cost profiles, however, could be utilized if a modular implementation strategy is selected.

The target level of 2004 to 2007 was used as a measure of the annual cash flow for each scenario, and it is referred to as the “leveled annual cost.” This cost is approximately the average annual construction cost of the first modules. In early receipt cases, the leveled annual cost is also affected by the waste receipt rates from 2007 through 2009.

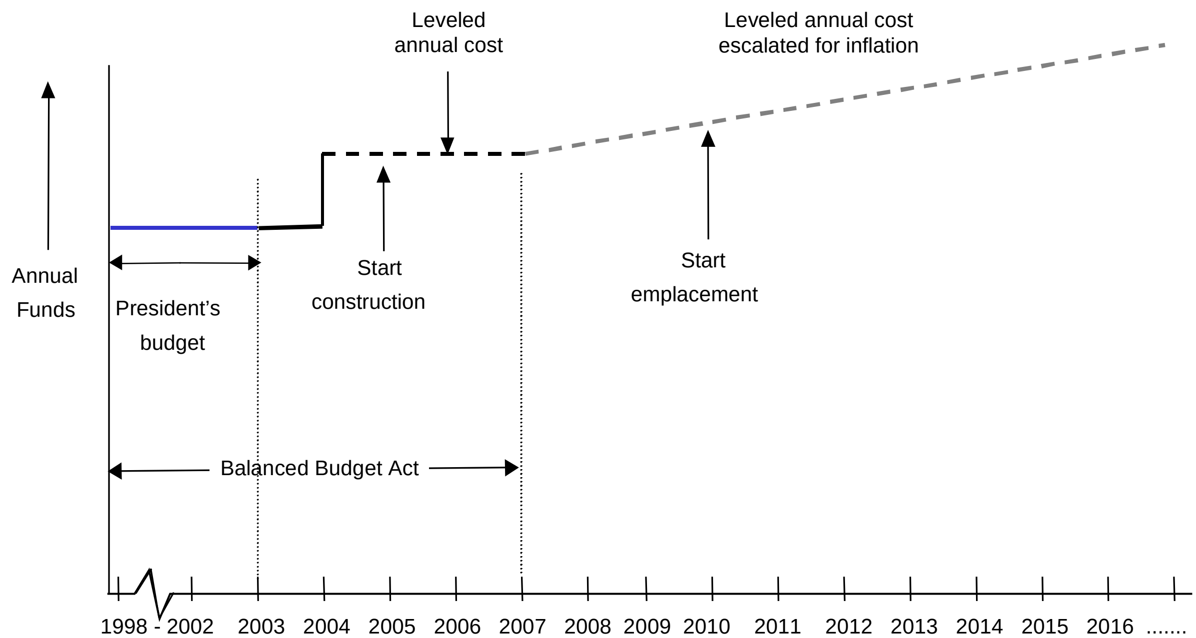

Figure 2-1. Target Annual Cost

Leveled annual cost is calculated from the costs in the years 2004 through 2009. The computation of the leveled annual cost for a specific scenario satisfies two constraints: (1) the sum of target costs from 2004 through 2009 must equal the total cost from 2004 through 2009, and (2) the surpluses between the target costs and the scenario annual costs must be great enough to equal deficits in future years. Surpluses could not be used as offsets for deficits prior to the year of surplus. Examples of representative scenario costs, the leveled annual cost, and the out-year target costs are illustrated in Figure 2-2.

With this approach, implementation scenarios with more expensive first modules have both larger leveled annual costs from 2004 through 2009 and larger target annual costs through 2020 than implementation scenarios with less expensive first modules. Therefore, scenarios with more expensive first modules will have more rapid completion of deferred modules than implementation scenarios with less expensive first modules. Scenarios with more expensive first modules could also receive waste more rapidly than scenarios with less expensive first modules.

The cost profiles of some scenarios with more expensive first modules become less than the target cost profile at some time after 2010. The funding needed in these scenarios would, therefore, decrease after 2010 from that indicated by the leveled annual cost target profile. The cost profiles of some scenarios with less expensive first modules become greater than the target cost profile at some point after 2010 because deferred facilities are constructed by 2020. The funding needed in these scenarios would, therefore, increase at some time after 2010 from that indicated by the leveled annual cost target profile.

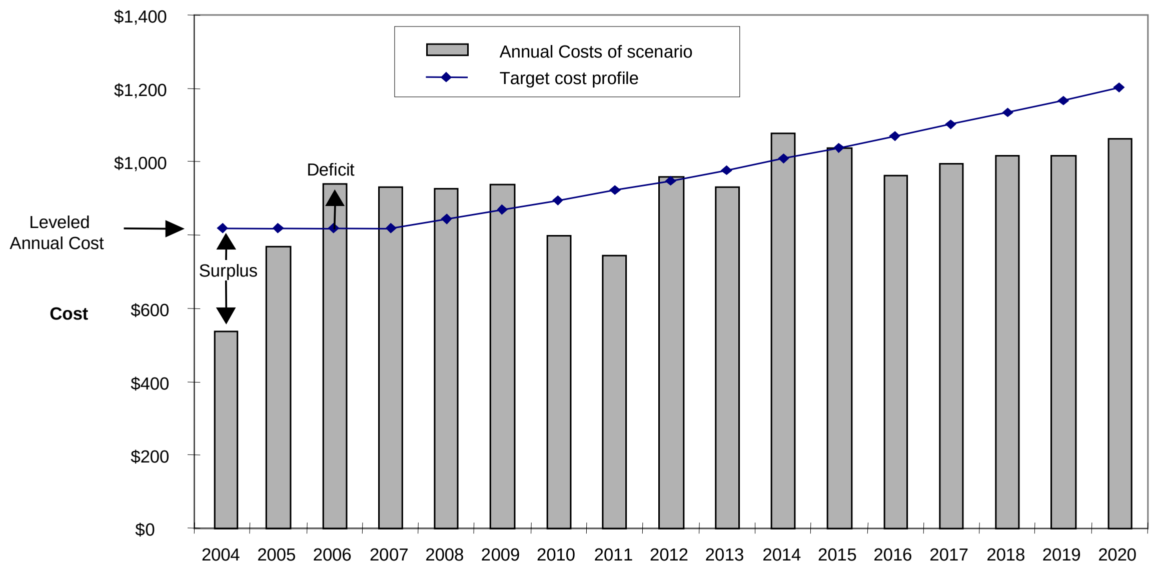

Figure 2-2. Examples of Scenario Costs, Leveled Annual Cost, and Target Cost Profile

In order to avoid biased comparisons of scenarios, two leveled annual costs are computed: the leveled annual cost that ensures that the target cost profile need not be increased until after 2010, and the adjusted leveled annual cost that ensures that the target cost profile need not be increased until after 2020. These two leveled annual costs and their corresponding target profiles are illustrated in Figure 2-3.

Scenarios for early receipt at the repository require temporary storage of the waste on the surface prior to the start of emplacement. The cost estimates assumed that all stored waste was repackaged prior to emplacement.

For this report, the effectiveness of all scenarios was estimated with emplacement of waste stored in repository surface facilities deferred until after 2020. Waste stored on the surface could, however, be retrieved from surface facilities and emplaced any time after emplacement operations begin. The emplacement of stored waste would involve use of the same surface facilities needed for transferring incoming waste from casks to disposal containers or storage. Consequently, emplacement of stored waste concurrent with waste acceptance could be accompanied by reduction in the rate of waste acceptance, and could, if included in a scenario, reduce the CRWMS effectiveness from that described in this report.

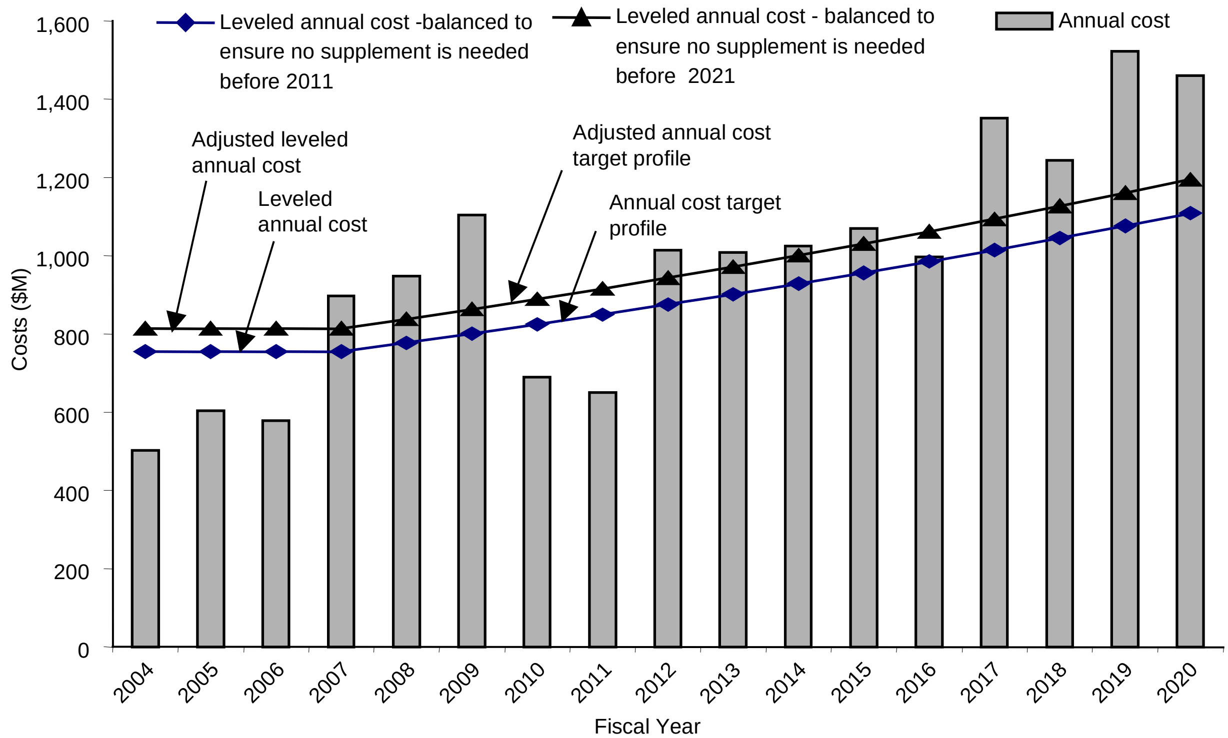

Figure 2-3. Illustration of Two Types of Target Cost Profiles

2.2 EFFECTIVENESS MEASURES

Eight effectiveness measures were used for describing the effectiveness of each program implementation scenario. The effectiveness measures included the total amount of the waste accepted, the amount stored in repository surface facilities, four measures of potential impacts on utilities, and two measures of total costs. The four measures of potential impacts on utilities were: (1) the number of shutdown reactor sites with empty pools, (2) the number of reactor sites where construction of new dry storage facilities could be avoided, (3) the number of reactor site-years that SNF would remain at shutdown reactor pools, and (4) utility costs for post-shutdown storage and pool maintenance. The two measures used for measuring total cost were (1) total system life cycle cost and (2) societal costs. Each of these measures is described in this section.

2.2.1 Total Waste Accepted

The total waste accepted is computed as the sum of the waste accepted through 2020. It is calculated separately for commercial SNF, naval SNF, DOE SNF, high-level waste without immobilized plutonium, and high-level waste with immobilized plutonium.

Commercial SNF could be delivered as canistered or uncanistered fuel. The amount of commercial SNF accepted by the CRWMS is measured in MTHM.

Naval SNF, DOE SNF, high-level waste without immobilized plutonium, and high-level waste with immobilized plutonium are to be delivered as canisters of waste. The amount of each of these four waste types is measured in number of canisters.

The analyses utilized a prioritization scheme for the naval SNF, DOE SNF, high-level waste without immobilized plutonium, and high-level waste with immobilized plutonium if the repository was not capable of receiving these wastes at the rates assumed for the reference program. Naval SNF had the first priority. Second priority was given to high-level waste with immobilized plutonium and high-level waste without immobilized plutonium sufficient for codisposal. Third priority was given to DOE SNF and high-level waste sufficient for codisposal.

2.2.2 Storage at the Repository

Scenarios were considered that included placing commercial SNF and naval SNF in dry storage before it would be emplaced in the subsurface facility. The cumulative MTHM of commercial SNF in dry storage was computed for 2009 and 2020. The year before emplacement in the subsurface facility begins is 2009, and 2020 is the ground-rule limit used for evaluating a scenario's effectiveness.

2.2.3 Number of Shutdown Reactor Sites with Empty Pools

The number of reactor facilities emptied was calculated for pickup of the waste through 2020. The number of facilities was calculated in two ways: (1) the number of sites from which all SNF was picked up, and (2) the number of reactor pools from which all SNF was picked up. It was assumed that no facilities would be emptied until 5 years after the reactors shut down. This is consistent with assuming that priority is assigned to fuel that is classified as standard fuel in accordance with the Standard Contract For Disposal Of Spent Nuclear Fuel and/or High-Level Radioactive Waste (10 CFR Part 961).

The method of waste acceptance prioritization affects the number of shutdown reactor sites with empty pools. The number of sites was computed using two methods of assigning waste acceptance priority. The baseline method is priority to reactors with the oldest-fuel. The second method employs priority to shutdown reactor sites. The number of sites with empty pools that could be achieved using the second method is referred to as "potential" number of sites with empty pools. Utilities would need to trade acceptance priority rights if the second method is to be used.

With the second method of waste acceptance prioritization, the total SNF picked up at a shutdown reactor site is the sum of two pickup rates. The first rate is the OFF allocation of the rate specified in the ACR. The second rate is the amount that can be allocated from the difference between the total pickup rate and the rate specified in the ACR. The calculation of this effectiveness measure assumes that the second rate is selected to maximize the number of reactor sites where pools are emptied.

The numbers of reactor sites permanently shut down are assumed to be those provided in the current projections. These assume that reactors not currently shut down will be operated until the expiration dates of their current licenses (DOE 1996c; CRWMS M&O 1996). These numbers are uncertain because the utilities could choose early reactor shutdown and reactor life extension, neither of which are included in the current projections. The number of reactor sites assumed to be shut down at least 5 years is shown in Figure 2-4.

2.2.4 Number of Sites where New Dry Storage Facilities could be Avoided

Utilities have constructed dry storage facilities to provide the additional storage capacity needed for continuing production of electrical power when there is not enough room left in the SNF pool to provide full core reserve. It is assumed in this analysis that utilities will continue to provide additional dry storage in lieu of other alternatives such as modifying fuel racks, consolidating fuel, shipping SNF to another pool, or shutting down the reactor prematurely.

The method of waste acceptance prioritization affects the number of sites where new dry storage facilities could be avoided. The number of sites was computed using two methods of assigning waste acceptance priority. The baseline method is priority to reactors with the oldest-fuel. The second method employs priority to sites where new dry storage facilities could be avoided. The number of sites where new dry storage facilities could be avoided using the second method is referred to as the "potential" number of sites where new dry storage facilities could be avoided. Utilities would need to trade acceptance priority rights if the second method is to be used.

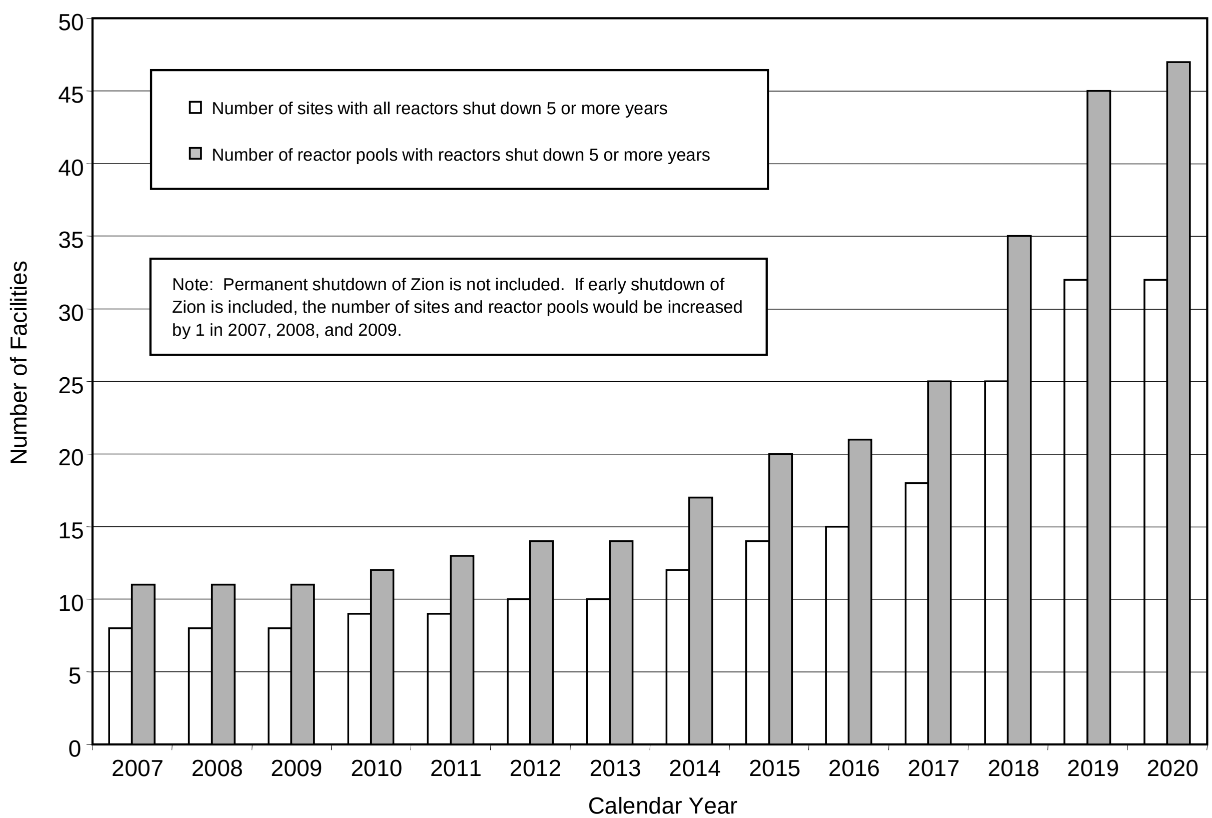

Figure 2-4. Projected Number of Reactor Sites Shut Down at Least 5 Years

The number of reactor sites projected to require new dry storage facilities if waste is not picked up is shown in Figure 2-5. Sixteen new utility dry storage facilities would be needed by 2020 if SNF is not picked up. The need for new dry storage sites depends on when the SNF is accepted and the rates at which it is accepted. No more than seven new dry storage facilities could be avoided if waste receipt starts in 2010. All 16 new facilities could be avoided with early receipt at the repository.

The annual rates of SNF acceptance are important in avoiding the needs for new dry storage facilities. With the second method of waste acceptance prioritization, the total annual rate that SNF is accepted from a site is the sum of two rates. The first rate is the portion of the ACR rate that is allocated in accordance with the OFF site priority allocation. The second rate is the amount that can be allocated from the difference between the total annual rate and the rate specified in the ACR. Estimates of this effectiveness measure assumed that the second rate was chosen to maximize the number of reactor sites where new dry storage facilities could be avoided.

2.2.5 Number of Reactor-Site-Years that Spent Nuclear Fuel Remains at Shutdown Sites

This effectiveness measure is related to utility costs that occur after a reactor no longer generates electrical power and before the site is emptied. This effectiveness measure is computed as the sum of the site-years at each site. The site-years at each site is the number of years that SNF remains at the site after the reactors on the site are shut down at least 5 years.

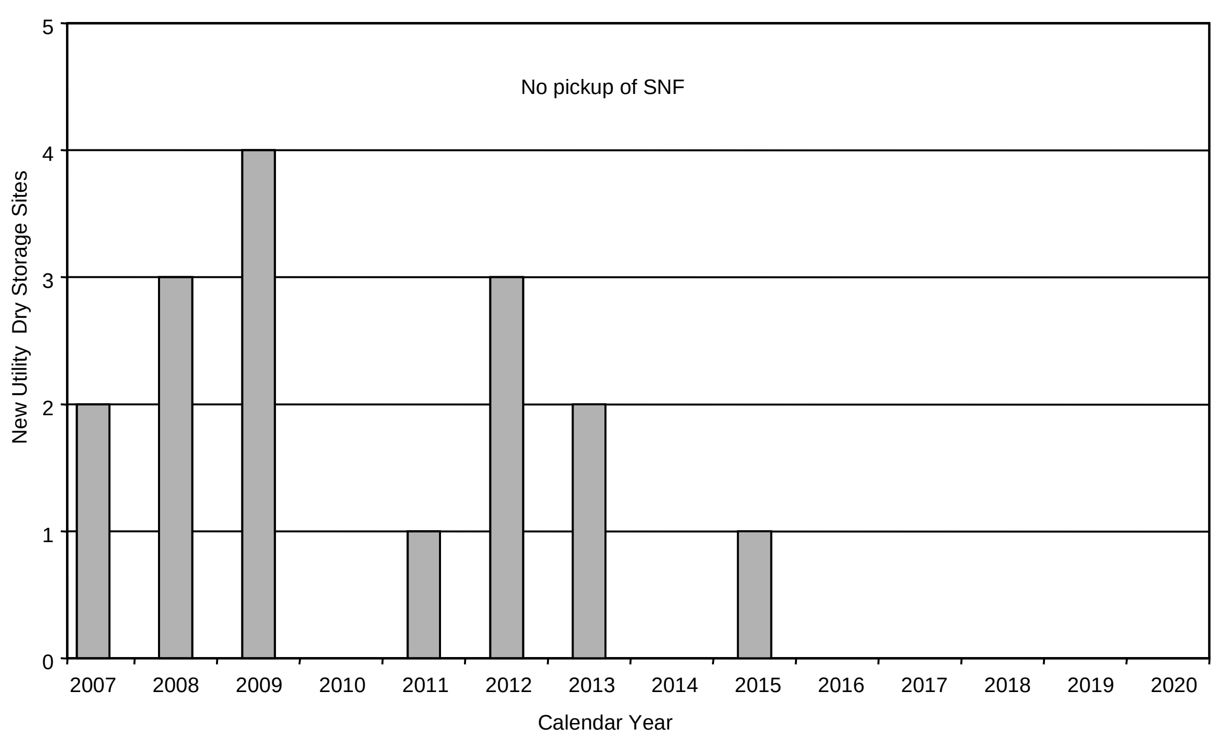

Figure 2-5. Projected Annual Number of New Dry Storage Sites without Pickup

The annual rates of acceptance and the years in which those rates occur are the two scenario characteristics that are important to achieving the smallest possible number of reactor site-years that SNF remains at shutdown site pools. The acceptance rates of commercial SNF at each reactor site are computed in a manner similar to that described in Section 2.2.3.

2.2.6 Total System Life Cycle Cost

The total system life cycle cost (TSLCC) is the cumulative of the annual cost for accepting, transporting, storing, and disposing of all wastes: commercial SNF, naval SNF, DOE SNF, high-level waste without immobilized plutonium, and high-level waste with immobilized plutonium. In order to compute the TSLCC, each implementation scenario was extended from 2020 through the years of accepting all wastes, monitoring repository effectiveness, and closing and decommissioning the repository. It was assumed that closure and decommissioning would be completed in 2116. The TSLCC is measured in constant 1998 dollars (98$). The methodology for determining the TSLCC is described in the TSLCC analysis for the reference scenario (DOE 1998a, Sections 1.7-1.8).

The discounted present value of the future expenditures was also computed because of the time value of money. TSLCC does not accurately reflect the fact that money spent in the near term has a greater financial impact than money spent many years from now. To take into account the time value of money, an average annual interest rate corrected for inflation was used to translate future expenditures into a "discounted present value." The discounted present value of expenditures is the amount of money invested today that would, with accumulated interest, be sufficient to cover the expenditures when they occur. The discounted present value is provided as 1998 dollars, the same as for the total system life cycle costs.

2.2.7 Utility Costs

Utilities will store SNF in dry storage at some operating reactors and some shutdown reactors after the CRWMS starts operating. In addition, pools will be maintained until they are no longer needed. This effectiveness measure estimates the costs for utility dry storage, maintenance of dry storage, and post-shutdown pool maintenance over the time period during which the nominal amount of all commercial SNF is accepted. The nominal amount of commercial SNF is approximately 86,000 MTHM, assuming no early reactor shutdown or reactor life extension (DOE 1996c; CRWMS M&O 1996).

The computations of this effectiveness measure are performed with the assumption that spent fuel would be stored in pools at shutdown reactors for at least 5 years after shutdown before it would be picked up by the CRWMS or unloaded into dry storage. Should all of the waste in a pool not be picked up by the fifth year after shutdown, or placed into dry storage, pool maintenance costs would be included as utility costs. With the baseline method of prioritization, pools were assumed to be unloaded into dry storage at sites capable of handling large casks that must be shipped by rail. With the second method of prioritization, however, pickup would be accelerated and it was assumed that pools were not unloaded into dry storage.

Utility costs are measured in constant 1998 dollars. The discounted present value of utility costs is also computed to take the time value of money into account. Utility costs include costs for dry storage.

2.2.8 Societal Costs

Societal costs are the sum of the TSLCC and utility costs. Discounted present value of societal costs is the sum of the discounted present values of the TSLCC and utility costs.